SCIENCE ABSTRACTS.

Section A.—PHYSICS.

NOVEMBER 1921.

GENERAL PHYSICS.

1882. *Measurement of Surface Tension; Apparatus.* **A. W. Fahrenwald.** (Mining and Sci. Press, Aug. 13, 1921. Chem. and Met. Eng. 25. p. 295, Aug. 17, 1921.)—The simple instrument described serves to measure the surface tension of liquids by determining the pull required to rupture a film of known width. A 2½-inch cork is pivoted on knife-edges and carries a vertical pointer indicating equal horizontal movements of the centre of gravity of the pointer. Over the cork is swung a No. 50 cotton thread carrying a weight counterbalancing a silver or aluminium stirrup, the horizontal member of which is 6 in. long, and is sharpened to a knife-edge at the bottom; at the ends of this member are small horns to prevent the film pulling away at the ends. Beneath the stirrup is a watch-glass supported on a ring and containing the liquid to be measured. If this is raised by means of a hand-wheel until the liquid engages the knife-edge and then slowly lowered, a plane film will be drawn out, tension in this film rotating the indicator. Two characteristic points will be observed—the first breaking in water, for instance, will swing the pointer up to about the 80-dyne graduation as the upper surface of the horizontal bar passes through the surface film; then, as the liquid is lowered further, a film will be drawn from the lower edge, and the pointer will drop to a constant reading, representing the true tension.

The method is independent of the wetting of the bar by the liquid to be tested. It measures the force required to break a film of considerable length, and a test occupies only a few seconds. The surface tension in dynes per cm. is given by the formula, $S = 981W/2L$, where W is the weight in grammes required to produce the observed deflection of the pointer, and L is the width of the film in cm. The influence of the horns may be estimated by drawing a film from them without allowing the knife-edge to touch the liquid. The method gives good results. T. H. P.

1883. *500-ton Compression Testing Machine.* (Engineering, 111. pp. 488–490, April 22, 1921.)—Describes a machine which has recently been erected in the National Physical Laboratory for making compression tests on stone and concrete. Essentially the machine is an oil press, the load being measured by the elastic elongation of the two main columns. The device for amplifying this elongation is fully described. J. L. H.

1884. *Modification of the McLeod Gauge extending its Range.* **A. H. Pfund.** (Phys. Rev. 18. pp. 78–82, July, 1921. Paper read before the Am. Phys. Soc., Washington, 1921.)—In order to extend the range of a McLeod gauge, the pressure of the gas which is forced into the capillary is measured by means of *a hot-wire gauge.* Since the ratio of the compression is known, it is possible to determine the true pressure. The hot-wire gauge consists of a loop of tungsten wire, sealed into the closed end of the capillary and connected so as to form part of a Wheatstone bridge. The hot-wire gauge is calibrated directly against the McLeod gauge. Because of the fact that the cooling effect varies with the character of the gas, a separate calibration for each gas is necessary.

Tests Made on the Gauge with Air.—Careful tests prove that the results obtained for air, the only gas used, are reliable. *The limit of the hot-wire McLeod gauge* was found to be $1\cdot7 \times 10^{-7}$ mm. Hg or $2\cdot25 \times 10^{4}$ bar, while that of the unaided McLeod gauge was found to be $5\cdot26 \times 10^{-5}$ mm. Hg. The range of the McLeod gauge is therefore extended three-hundred-fold. By using a sensitive wall galvanometer in place of the portable galvanometer, a sensibility of $3\cdot4 \times 10^{-10}$ mm. or $4\cdot5 \times 10^{-7}$ bar was realised. AUTHOR.

1885. *Mercury Vacuum Pump.* **G. Ranque.** (Comptes Rendus, 172. pp. 1653–1654, June 27, 1921.)—The author describes a simple and inexpensive form of mercury pump, requiring only about 400 gm. of mercury for its operation. It is necessary, however, to use an auxiliary pump to reduce the initial pressure to 6 or 8 cm. A kathodic vacuum (of the order of 0·01 mm.) can be obtained in a container of 50 cm.^{3} in about 15 minutes. A. B. W.

1886. *Anschütz and Sperry Gyro-Compasses.* **H. Beghin.** (Comptes Rendus, 173. pp. 288–290, Aug. 1, 1921.)—A mathematical treatment giving the equations satisfied by the three gyrostats of the Anschütz compass and by the two gyrostats in the latest form of the Sperry compass. E. H. B.

1887. *Possibilities of New Types of Horary Movements.* **J. Andrade.** (Comptes Rendus, 173. pp. 130–131, July 18, 1921.)—The paper consists of a mathematical investigation of the laws governing pendular movements and escapements. A special condition is arrived at with the combination of eight associated spirals actuating a floating balance and an electromagnetic escapement with two electromagnets, which reduce the shock of the escapement by an impulse couple. A. B. C. L.

1888. *Measurement of Single and Successive Short Time-Intervals.* **A. Pollard.** (Nature, 109, p. 585, July 7, 1921.)—A modification of the well-known method of determining small time intervals by the discharge of a condenser consists in connecting one side of the condenser to the string of a Laby string electrometer. The displacement of the string is proportional to the potential of the condenser, so that during an experiment the string falls from one position to another, and the logarithm of the ratio of these displacements from the zero position is proportional to time. The accuracy of the method can be increased by using a moving plate and photographing the string's position; it can be increased up to the limit of the accuracy within which the condenser capacity and discharging resistance are known, by measuring the displacements on the plate with a microscope. The advantages of this method, as compared with the ballistic method, are: (1) The procedure and circuit are much simplified, (2) small leakage is of no importance, (3) the process is self-recording. The inertia of the string, and its natural period of vibration, do not affect the result. A. B. C. L.

1889. *Ordnance Problems.* **G. F. Hull.** (Frank. Inst. J. 192 pp. 327–347, Sept., 1921.)—Describes electrical methods of timing the passage of a projectile through solenoids, an oscillograph being used to give the records. E. H. B.

1890. *A Photochronograph; Application to the Determination of Fitzgerald-Lorentz Contraction.* **J. H. Coblyn.** (Rev. Gén. d'Él. 10. pp. 392–393, Sept. 24, 1921. Paper read before the Assoc. franç. pour l'Avancement des Sciences, Rouen.)—In order to measure accurately the time corresponding to a fraction of the S.H. vibration of a tuning-fork, a beam of light from a source distant about 200 m. is directed upon a lens, the upper half of which brings it to a focus directly upon a kinematograph film, and the lower half after reflection from a mirror attached to an end of the fork, the foci coinciding when the fork is at rest. The plane of vibration of the fork is perpendicular to the movement of the film. With an intermittent source of light, the amplitude of the sine curve and the distance between the two images give the phase at the beginning and end of each flash. The time scale is simultaneously impressed on the film by a standard clock, and the author claims a precision of 1/80,000 sec. By the addition of a mirror rotating about an axis perpendicular to the travel of the film in such manner that the traces of the direct images and of those reflected from the rotating mirror are photographed on the film, the instantaneous travel of the film and speed of the mirror can, the author states, be so accurately determined as to give the apparatus a precision of 1/2,400,000 sec.

The author suggests the possibility of applying the apparatus to determining the reality or otherwise of the Fitzgerald-Lorentz contraction. Two tuning-forks are to be mounted with their planes of vibration at right angles to each other on a plate to which both are parallel, and the plate is so placed as to contain the direction of the contraction. The axis of each fork in succession is to assume this direction by turning the plate through 90°, and Lissajous figures from the two forks being received by both the rotating mirror and the photochronograph, a difference of phase should be perceptible within ten seconds if the contraction be a real one. G. W. de T.

1891. *Correction of a Marine Barometer for Errors due to Swinging.* **W. G. Duffield** and **T. H. Littlewood.** (Phil. Mag. 42. pp. 166–173, July, 1921.)—If a barometer is inclined to the vertical at an angle α the height of the mercury becomes $h \sec \alpha$, where h is the reading in the vertical position. In a marine barometer in which the tube has a constricted portion designed to avoid "pumping," the height assumed by the mercury in the tube, if the instrument is swinging, is the mean value of $h \sec \alpha$ throughout the swing, and from this cause alone the reading is too high by an amount which may be of importance. There is, however, a compensating action, for the centrifugal force acting on the mercury during the oscillation tends to depress it in the tube. The error δh caused by the two effects combined is given to the second order in a_0 by $\delta h = \frac{1}{4} h a_0^2 (1 - 2d/l)$, where a_0 is the extreme deviation from the vertical, l the length of the equivalent simple pendulum, and d is the distance of the centre of pressure of the mercury in the tube from the point of support. Thus the error is zero if $l = 2d$. Experiments with a marine barometer showed that the relation was not satisfied, and further experiments showed that an adjustment is quite practicable either by loading the instrument, by which means l alone is altered, or by moving the point of support, which affects both l and d. Incidentally the above formula for δh was verified. The adjustment once made should hold good for all small amplitudes of swing, since a_0 is not involved to the first order. It appears that this should be done both for meteorological purposes as well as for more refined gravity work at sea. For special accuracy a further correction is necessary owing to the changes in the height of mercury in the tube and of the position of the sliding scale. This correction might take the form of a second sliding weight.

M. A. G.

1892. *Design and Construction of Scientific Instruments.* **R. S. Whipple.** (Optical Soc., Trans. 22. No. 2. pp. 35–52, 1920–21. Presidential Address to the Optical Soc., Feb., 1921. Engineering, 111. pp. 659–662, May 27, 1921.)—A general resumé of the principles underlying the design of scientific instruments. The author states that the three problems to be considered are the accuracy and sensitivity required and the cost allowable. The accuracy requirements are as follows :—(*a*) An instrument must have the required accuracy ; (*b*) it must have a constant accuracy ; (*c*) every important source of inaccuracy should be known ; (*d*) any error should be, as far as possible, capable of elimination by adjustment ; (*e*) this adjustment should be possible without the addition of other special apparatus ; (*f*) when an error cannot be eliminated it should be as constant as possible ; (*g*) when an error cannot be eliminated it should be capable of measurement by the instrument itself without external apparatus so that the results may be corrected. The different methods of constraining any body are described, and their use in scientific instruments is exemplified and illustrated by diagrams. The various problems connected with the use of scales are mentioned—namely : position, relation of mark lengths to division widths, size of figure, and proportion of height of figure to thickness of line. The author emphasises the fact that the instrument of to-day is the tool of to-morrow, and he mentions that in America instrument firms have organised development departments whose function it is to modify the design of a laboratory instrument in such a way as to render it suitable for use in the workshop.

J. W. T. W.

1893. *Double Pendulum.* **H. S. Rowell.** (Nature, 107. p. 684, July 28, 1921.)—Let M and m be the masses of the bobs of a double pendulum, and let A and a be their respective amplitudes with suffixes 1 and 2 to denote the modes ; then $A_1A_2/a_1a_2 = -m/M$. E. H. B.

1894. *Pendulum Experiments.* **J. Satterly.** (Roy. Soc. Canada, Trans. 14. Sec. 3. pp. 27–35, 1921.)—Describes a series of laboratory experiments in use at Toronto with a pendulum having a heavy spherical

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iron bob and long fine steel-wire suspension from the ceiling. With this pendulum, besides the obvious exercises, Young's modulus is found for the steel suspension (also the rigidity), the transverse and longitudinal vibrations of the wire are studied, and experiments on impact are carried out. E. H. B.

1895. *Resistance of Materials.* **L. de Karasinski.** (Comptes Rendus, 173. pp. 132–134, July 18, 1921.)—The deformation set up by a system of external forces acting on an elastic solid is investigated mathematically. The conditions for stable, unstable, and ambiguous elastic equilibrium are developed. A relationship serving as a measure of fatigue is given. A. B. C. L.

1896. *Strength of the Reinforced Thin-Plate Beam.* **B. C. Laws.** (Phil. Mag. 42. pp. 281–287, Aug., 1921.)—In previous papers [Abs. 509 (1916)] solutions were given for the problem of the thin-plate beam, fixed at its ends and subjected to a uniformly distributed load. In the present paper an extension of the problem is considered, wherein the thin plate is partially stiffened so that the inertia value of the beam section is not constant from end to end of the beam. A. W.

1897. *Brinell Hardness Tests.* **F. Waizenegger.** (Zeits. Vereines deutsch. Ing. 65. pp. 824–827, July 30, 1921.)—Brinell proposed to use a pressure P of 3000 kg. for hard materials and of 500 kg. for soft materials when working with balls of 10 mm. diam. (D). The 3000 kg. is hardly sufficient for hard steel and too high for soft iron. The author shows, on Eugen Meyer's lines, how results can be obtained which are comparable for different materials and independent of P and D. Measuring the diameter d of the base of the impression calotte, Meyer found $P = ad^n$ in kg., where n varies between 2·0 and 2·6 and a refers to $d = 1$ mm. When n is known $a_1D_1^{n-2} = a_2D_2^{n-2} = aD^{n-2} =$ a constant A in kg./mm.², so that $P = Ad^n/D^{n-2}$ kg. When we plot the relative hardness values H against P, we obtain a curve, the maximum of which is the author's $H_{max.}$ for which he deduces a formula containing only A and n. Tables and curves are given for facilitating the calculations, and it is further shown how the relations between ball hardness and tensile strength and the influence of heat on the hardness of metals after Kürth (*ibid.*, pp. 85 and 209, 1909) can be investigated. H. B.

1898. *Vibrations of a Spinning Disc; Failure of Turbine Discs.* **H. Lamb** and **R. V. Southwell.** (Roy. Soc., Proc. 99. pp. 272–280, July 1, 1921.)—This paper treats of the transverse vibrations of a circular disc of uniform thickness rotating about its axis with constant angular velocity. The problem has a practical bearing, as throwing light on the occasional failure of turbine discs. The vibrations of a non-rotating disc were fully discussed by Kirchhoff (Crelle's Jour. 40, 1850, and Pogg. Ann. 81, 1850). If on the other hand the disc is so thin and the rotation so rapid that the flexural forces are negligible, the principal tensions are along and perpendicular to the radius vector. The equation for transverse motion of an element of area is easily derived, and, assuming that w the normal displacement varies as $\cos s\theta \cos p_1t$, where s is integral and p_1 is the frequency of vibration, it is put into a form which can be integrated by a series. The mode of vibration thus found has n nodal circles and s equidistant nodal diameters and the frequency is given by a simple equation containing terms which depend on s, n, w, and Poisson's ratio, but not on the diameter and thickness of the disc. If $s = 0$ the centre of the disc is displaced. If $s = 1$ and $n = 0$ the disc remains plane in form but is slightly untrue to the axis. Neither of these cases corresponds to the physical problem under investigation. The most interesting modes, which can be realised easily experimentally with a rotating india-rubber membrane, are those in which there are no nodal circles. When $s = 2$ there are two nodal diameters at right angles and $p_1^2/W^2 = \frac{1}{2}(5 - \sigma)$, where σ is Poisson's ratio. For india-rubber σ is practically $\frac{1}{2}$ and $p/W = 1 \cdot 5$. For steel vibrating in this mode $p^2/W^2 = 2 \cdot 35$, σ being taken as $0 \cdot 3$. The vibrations considered are vibrations relative to the undisturbed disc; it is, of course, possible to deduce that the angular wave velocities *in space* are $w \pm p_1/s$. These results are approximated to as the speed of rotation is increased. In the other extreme the results of Kirchhoff may be made use of. These are of the form $p_2^2 = \mu \, Eh^2/\rho a^4$, where E is Young's modulus, h the half thickness, ρ the density, a the radius, and μ is a numerical coefficient depending on the mode of vibration and to some extent on the value of σ. For the mode of vibration with two nodal diameters and no nodal circle Kirchhoff calculates $p_2/\pi = [(Eh^2/\rho a^4) \times 1 \cdot 04604]^{1/2}$ for $\sigma = \frac{1}{4}$ and $p_2/\pi = [(Eh^2/\rho a^4) \times 1 \cdot 20357]^{1/2}$ for $\sigma = \frac{1}{2}$. An independent calculation gives the value of μ in this case as $10 \cdot 61$, σ being taken as $0 \cdot 3$.

It is difficult to obtain an exact solution when the centrifugal tensions and the flexural stiffness are both effective, but approximations which are adequate from a practical point of view can be obtained for the more important modes of vibration by Rayleigh's method of an assumed type (Theory of Sound, §§ 88, 89). The potential and kinetic energies are calculated on the basis of an assumed form of w and the frequency is determined which makes the mean energies of the two kinds equal. Assuming $w = \phi(r_1\theta) \cos pt$, it is found that the formula $p^2 = p_1^2 + p_2^2$ gives an approximation which is of the nature of a *lower limit* to the true value.

Taking $E = 2 \times 10^{12}$, $\rho = 7 \cdot 8$, $a = 60$, $h = 1$, $w = 100\pi$, in C.G.S. units and $\sigma = \frac{1}{4}$ we get $p/\pi = 213 \cdot 07$ for the gravest mode with two nodal diameters. Assuming $w = (1 + \beta r^2/a^2)(r/a)^s \cos s\theta \cos pt$ the calculations can be carried out by suitably altering the value of β so as to obtain an *upper limit* to the true value. This has been calculated for the above case and the result obtained $p/\pi = 213 \cdot 74$. This is probably very close to the true value, but the lower limit previously obtained differs from it by only about $\frac{1}{3}$ % and is obtained with much less labour.

H. N. A.

1899. *On a Type of Vibration in an Elastic Spherical Shell.* **N. Sen.** (Phil. Mag. 42. pp. 185–193, July, 1921.)—It has been shown by Love (Lond. Math. Soc., Proc. 2. p. 88, 1904) that the damping factors are very important in the case of the vibrations of a spherical shell in a gaseous medium. The motion is generally damped harmonic and, to the first order of approximation, is simple harmonic for the sphere, and partly simple harmonic and partly exponential for the medium. The waves of rapidly damped harmonic type, which are almost insensible a short distance from the sphere, come into promi-

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nence again near the surface of discontinuity of the advancing disturbance, and are responsible for the fulfilment of the necessary condition at this boundary. In the present paper the shell is taken to be elastic, the interior contains no gas and the shell is thin. It is found that for certain ratios between the thickness and radius of the shell the motion is aperiodic, and the initial strain is got rid of, the energy being communicated to the outside air, without any vibrations. In the case of glass this is shown to be the case if this ratio lies between $0{\cdot}37 \times 10^{-5}$ and $0{\cdot}1 \times 10^{-4}$. For ratios outside these limits the shell executes damped harmonic vibration, attended by a dissipative motion, given by an exponential term. The recovery of the shell from the strain corresponding to this part of the displacement becomes quicker as the thickness diminishes, and is almost immediate below the above critical thickness. For a shell of given radius, as the thickness decreases, the period of vibration increases and also the damping coefficient, until the upper critical thickness is reached. Below the lower critical thickness there is a steady fall in the value of the coefficient, but the period goes on increasing. When the thickness is large the period of vibration does not differ much from the free period *in vacuo*. The motion of the surrounding medium is of the same kind as that described by Love. H. N. A.

1900. *Tangential and Radial Resistance of a Fluid to a Rotating Body; Application to the Isochronism of the Conical Pendulum.* **R. Serville.** (Comptes Rendus, 173. pp. 404–407, Aug. 22, 1921.)—A special *apparatus*, including an electrically-balanced system of pulleys, is described, by means of which the total resistance couple opposing rotation can be measured, independently of the speed of rotation. By deducting the resistance couple obtained with the body removed from the apparatus, the resistance couple due to the body is obtained. The relationships of the readings obtained from the apparatus to the resistance couples to be measured are expressed in mathematical form. It is shown how the arrangement can be adapted to the measurement of the radial component of the resistance and to the actuation and isochronism of the conical pendulum. A. B. C. L.

1901. *Dynamics of Revolving Fluid on a Rotating Earth.* **D. Brunt.** (Roy. Soc., Proc. 99. pp. 397–402, Aug. 2, 1921.)—Rayleigh has considered some time ago the case of fluid revolving about a fixed vertical axis, neglecting the rotation of the earth [Abs. 287 (1917)]. The present paper introduces the rotation of the earth and translation in a vertical plane of the axis of symmetry. The viscosity and compressibility of the fluid (air) are neglected. The equations of motion and the equation of continuity are given and it is shown that a uniform velocity of translation U may be added, provided the pressure distribution be corrected by the addition of a horizontal gradient of pressure $2\omega\rho U \sin\phi$ at righ angles to U. The equations of motion are then given with reference to cylindrical coordinates r, θ, z and Rayleigh's vorticity ζ and streamline function ψ are introduced with $w = 0$ and it is shown that $\mu = -B/r$ and $v = 2/r\int\zeta r\,dr + A/r$, where A and B are independent of r and θ, but may vary with time t. In the case where the fluid has an initial rotation as a solid body, with angular velocity ζ, there is a ζ initially and therefore permanently constant throughout the fluid, and the last equation becomes $v = \zeta r + A/r$. The effect of convergence towards the axis is to superpose on the rotation as a solid body a simple vortex of intensity A. The rotation of the earth affects the determination of the value of A at any given time. The rotating fluid may be supposed to be contained within a cylindrical wall, which moves inward as the fluid converges, fluid being removed along the axis without disturbing the horizontal motion. R_0 is the radius of the wall at time $t = 0$ and R at time t. Initially the fluid is supposed to rotate as a solid body, so that initially $A = 0$. It is shown that $v = \zeta r + (\zeta + \omega \sin \phi)(R_0^2 - R^2)/r$. This differs from Rayleigh's equation (19) only by the inclusion of the term $\omega \sin \phi$ which represents the rotation of the earth. The effect of the earth's rotation is to increase the strength of the superposed simple vortex. When there is originally no rotation or $\zeta = 0$, $v = \omega \sin \phi (R_0^2 - R^2)/r$ when air is removed, producing a simple vortex. If a cyclone starts as a uniformly rotating disc of radius R_0, with uniform angular velocity ζ, the effect of removal of fluid along the axis is to cause R_0 to shrink to R. Within the cylinder of radius R a simple vortex whose intensity increases as the removal proceeds is superposed on the uniform rotation. Outside the cylinder R the change of motion caused by convergence is represented by a simple vortex. The amount of fluid removed from a layer of the vortex of unit thickness in time t is found to be $\pi(R_0^2 - R^2)$, so that the intensity of the simple vortex produced by the convergence is directly proportional to the total amount of fluid removed from the region of the axis. A formula for the distribution of pressure is also obtained.

The results may be applied to the case where air is supplied at the axis, involving a progressive increase of the extreme radius R of the disc of fluid concerned. The dynamical effect is to superpose on the original distribution of velocity a simple vortex of negative intensity, or rotating clockwise. A region of descending air should therefore acquire a clockwise rotation with velocity inversely proportional to the distance from the centre of the axis of revolution. If the outer radius R_0 increases to R in time t and the added air is bounded by a cylinder of radius R′ at the same instant, then, within the added fluid, where $r < R'$, there is clockwise rotation like a solid with angular velocity $\omega \sin \phi$. Between R′ and R there is a combination of an anticlockwise rotation like a solid mass and a clockwise simple vortex, while outside R there is a clockwise simple vortex. The stream-lines of instantaneous flow in the general case are given by $re^{\zeta r^2/2A} = Ce^{-BA\theta}$ where $B = -\mu r$. They are spirals whose angle of convergence increases towards the centre except when $\zeta = 0$ and the motion is a simple vortex, in which case the stream-lines are equiangular spirals.

In all that precedes the centre of the two-dimensional whirl has been assumed at rest. With a uniform velocity of translation U the distribution of velocity and the spiral paths of instantaneous flow relative to the centre of the whirl are unaltered. A correcting term $-2\omega \sin \phi U y$ must be added to the equation for the pressure distribution. H. N. A.

LIGHT.

1902. *Measuring the Gloss of Paper; Apparatus.* **L. R. Ingersoll.** (Optical Soc. of America, J. 5. pp. 213–217, May, 1921.)—Describes an instrument, termed a "glarimeter," for determining the degree of gloss of paper. The instrument actually measures the proportion of light which is polarised by reflection from the surface of the paper, as this is the portion regularly reflected. The scale of degree of gloss is an arbitrary one, being the reading in degrees of the position of an analysing nicol. Although the instrument gives the optical, as distinct from the mechanical, gloss, it is found that the two are so closely connected that one may be used instead of the other for the control of the calendering process. Different kinds of paper must be compared on different scales. For example, a darkening of the tone of a paper increases the gloss reading, since it reduces the amount of diffusely reflected light, without appreciably affecting the amount specularly reflected. J. W. T. W.

1903. *Seemann X-Ray Spectrograph for Precision Wave-length Measurement.* **W. Vogel.** (Zeits. f. Physik, 4. 2. pp. 257–261, 1921.)—The paper gives a detailed description of the Seemann spectrograph, with examples of the accuracy attainable in X-ray wave-length measurement by means of the device. For details the original should be consulted. A. B. W.

1904. *Dispersion in the Electric Spectrum of Water.* **K. Iwanow.** (Ann. d. Physik, 65. 6. pp. 481–506, Aug. 30, 1921.)—The method employed in this investigation was similar to that of Colley [Abs. 121, 122 and 1103 (1909), and 677 (1910)]. The range covered by the experiments was from $\lambda/2 = 300$ mm. to $\lambda/2 = 620$ mm. It was found that from $\lambda/2 = 333$ mm. to $\lambda/2 = 594$ mm. the electric spectrum of water has a complicated structure, consisting of a large number of narrow dispersion bands. These bands appear to be arranged in a manner similar to the lines in band spectra. In addition to the region free from dispersion found by Colley, another such region was found from $\lambda/2 = 594$ mm. to $\lambda/2 = 620$ mm. In these two regions the dependence of the refractive index on temperature was investigated, and the results are shown graphically. With increasing temperature the bands show a tendency to vanish at about 50° to 60°, though this cannot be stated definitely. The absorption of the waves decreases with increasing temperature. The effects observed can be explained by assuming that the dispersion centres consist of large molecular aggregates, which are split up when the temperature rises. A. W.

1905. *Colours of "Breathed-on" Plates.* **C. V. Raman.** (Nature, 107. p. 714, Aug. 4, 1921.)—If a clean, cold plate of glass is lightly breathed on and then a small distant source of light is viewed through it, coloured haloes are seen surrounding the source. The characteristic feature of the halo exhibited by a moderately heavy (but not too heavy) deposit is that the outermost ring is achromatic, with a reddish or brown inner margin, followed by a succession of rings of various colours. As the film of moisture evaporates, the halo contracts and the coloured rings move inwards, ultimately disappearing, are seen under the microscope to preserve the same configuration with a surprising degree of accuracy.

Doulé and Exner have supposed either that the minute droplets of water condensed on the plate which diffract the light are of approximately equal size or that they are arranged at more or less constant distances from one another. A microscopic examination of the condensed film shows, however, that neither of these suppositions is anywhere near the truth. A more probable explanation is to be found in the fact that measurements seem to show that the droplets, whether large or small, have practically all the same angle of contact with the surface of the plate, this angle of contact diminishing as the film evaporates. The formation of the coloured haloes is, on this view, due to the passage of light through the minute lens-shaped droplets; the max. deviation of the light determined by the common angle of contact fixes the position of the outermost achromatic ring, and the colour sequence following within it would be practically the same for all the droplets irrespective of their size. This would also furnish a satisfactory explanation of the contraction of the halo as the film evaporates. A. W.

1906. *Curves of Blackening.* **H. Arens.** (Zeits. wiss. Phot. 21. pp. 28–36, July, 1921.)—In the use of polarisation photometers results are obtained when visual comparison is made which are different from those when a photographic method is employed, this being due to the difference in sensitiveness of the eye and the photographic plate to light of various wave-lengths. The bearing of this on photographic reduction and intensification of negatives is discussed. A. W.

1907. *The Lighting and Resolving Power with High-Frequency Kinematographs.* **A. Klughardt.** (Zeits. Instrumentenk. 41. pp. 201–212, July, 1921.)—In a previous paper [see Abs. 1389 (1919)] the author has obtained an equation for the resolving-factor μ, and in the present paper, which is also of a mathematical nature, equations are obtained for the cases when the motion is horizontal and when it is vertical. A. E. G.

1908. *Systems of Colour Standards.* **A. Ames, Jr.** (Optical Soc. of America, J. 5. pp. 160–170, March, 1921.)—Devices for enabling the colour of any object to be determined may be based either on the use of a colorimeter or a standard composed of coloured cards. The latter method is the simpler and is considered in this paper. Such a standard must satisfy requirements as regards arrangement, nomenclature, number, spacing, and standardisation. All colours may be defined in terms of *hue* (wave-length), *chroma* (saturation), and *value* (brightness). Munsell has devised the most perfect representation of colours in terms of these factors. In arranging the system, it is preferable to keep the value constant with changing colour and saturation. Accordingly all colours of the same hue or wave-length are arranged on one chart, and a series of charts is provided. In the Munsell system *hue* is designated by a letter, *value* by a number above a line */* to the right of the letter, *chroma* by a number below this line. The author concludes that there should be 50–80 steps in hue, 70–100 in value, and 35–50 in chroma, giving a total of about 13,000 different cards, for complete analysis. As regards spacing, the degree of separation should be the same throughout the entire system. Standardisation should be effected by calculating the three constants for each card and obtaining the conditions with a colorimeter, the result being reproduced on cards. In conclusion the author discusses Ridway's system, which is probably the most used to-day, but does not completely satisfy the conditions prescribed for a colour-standard.

J. S. D.

1909. *Magnetic Double Refraction in Smokes.* **L. Tieri, R. Whytlaw-Gray.** (Nature, 107. pp. 778–779, Aug. 18, and p. 810, Aug. 25, 1921.) —E. Thomson's letter [see Abs. 1751 (1921)] suggested to the author that the phenomena were associated with magnetic double refraction. A parallel beam of plane-polarised light from a Nernst lamp was passed over the middle of a horizontal, flat circular coil. Below the coil, an arc lamp carrying 30 amps. at 140 volts gave large quantities of smoke from iron electrodes. When the field was on, the light passed through the crossed nicols. Further, with monochromatic light, extinction is not reached by turning the analyser. If the field is powerful enough, the effect appears also with smoke from copper electrodes.

Tieri's observations are in accord with the views advanced by E. Thomson and by Speakman and Whytlaw-Gray. The arrangement of the particles along the lines of force indicates a non-spherical shape of the particles. This was confirmed by microscopic examination. The fumes in air undergo rapid changes with time under the action of molecular bombardment, and it might be expected that the magnetic double refraction would vary with the age of the smoke and its method of production. The bluish coloured smoke which does not exhibit the effect consists probably of single particles. The effect observed by Tieri in iron oxide is similar to that noted by Cotton and Mouton in the same substance dispersed in water. G. E. A.

1910. *Rotivity in Crystalline Media.* **L. Longchambon.** (Comptes Rendus, 173. pp. 89–91, July 11, 1921.)—Pasteur's observations of the relationships between the crystalline forms of bodies possessing the power of optical rotation and their rotivities in the liquid state or in solution are referrred to and discussed in relation to later conceptions. A list of substances optically active in solution which have been studied in the crystalline state is given and they show, without exception, rotivity in the direction of the optical axes. It is concluded that structural rotivity can be considered to be an inevitable consequence of crystalline asymmetry. Numerical results obtained are given for the twelve substances investigated—the very high figures for ammonium molybdate and iodic acid being noteworthy. A. B. C. L.

1911. *Spectra of the Alkaline Earth Fluorides.* **S. Datta.** (Roy. Soc., Proc. 99. pp. 436–455, Aug. 2, 1921.)—It is well known that the limits of the series and the separation of the doublets and triplets, which occur in the line spectra of chemically related elements, are intimately connected with the atomic weights of the elements involved. It seemed reasonable to suppose that numerical relations might also exist in the case of band spectra, and the present paper gives an account of investigations undertaken to determine possible relations among the band spectra of similar compounds of different elements. The fluorides of the alkaline earth metals were chosen, and a more complete survey of the spectra of these compounds showed the existence of several new bands which have been of considerable service in the identification of corresponding bands in the different spectra. Nine series of bands were observed in the spectrum of MgF_2. Four new series have been found for CaF_2 in the ultra-violet, and additional heads recorded in some of the series in the visible region. Four new series have been found for SrF_2 in the ultra-violet, and a very weak one in the red. Series designated as H_1, H_2, H_3, H_4, and ascribed to SrF_2 by Leopold [Abs. 1030 (1912)], also the same series called F_1, F_2, F_3, and allotted to BaF_2 by George [Abs. 1434 (1913)], have been proved to be really due to CaF_2. The homologous series of the different alkaline earth fluorides have been connected by empirical equations which involve the series constants and the molecular weight or the molecular numbers of the respective compounds. An explanation is given of the appearance of a "tail" in some of the bands, starting with their series equations. It is also shown that the difference in wave-numbers of the heads and tails of similar series is constant for the same compound, but varies from one compound to another in a definite way. **A. W.**

1912. *New Spectrum of Caesium.* **L. Dunoyer.** (Comptes Rendus, 173. pp. 350–352, Aug. 8, 1921.)—Spectra of rubidium and caesium, which are almost entirely new, have been obtained by producing luminescence in the vapours of these elements by means of electromagnetic induction. The present paper is concerned with caesium. For this substance wave-length measurements have been made of about 630 lines, from λ2250 to λ6300. In this region only about 120 lines were known previously. The spectra consist of fine lines, many being intense, with no trace of a continuous background. A tube of fused quartz, with ends of plane parallel quartz, contained the pure metal; this tube was surrounded by a dozen turns of thick copper wire connected to a high-frequency source; the tube and copper spiral were placed in an electric furnace with double glass walls. A Féry spectrograph was used, and this was provided with a temperature regulator, the latter being indispensable for long exposures. *Different spectra.*—At the ordinary temperature the tube remained dark on passing a discharge through the spiral. Towards 100° C. an intense pale blue glow appears, which increases in intensity as the temperature is raised and then changes, if not suddenly at least very rapidly, till at 250° the colour of the glow is a rosy salmon. On further raising the temperature, the luminescence fades and finally disappears. On lowering the temperature again, the same effects are exhibited in the reverse sense. During the transition period the two tints can exist simultaneously in different parts of the tube. The effect seems to depend not merely on the temperature, but on the pressure of the vapour. The change of tint is accompanied by a radical modification of the spectrum. Under relatively large pressure the spectrum comprises a small number of lines, among which have been identified the blue doublet of the principal series and the more intense (and more refrangible) component of the first ultraviolet doublet. At low pressure these three lines become fainter, while a very great number of other lines appear which belong neither to the principal series nor to the first subordinate series. Comparison with the spectra of caesium hitherto known shows that identifications are rare and doubtful for the flame spectrum, for the arc spectrum, and also for the vacuum tube spectrum (Goldstein). On the contrary, all the spark lines obtained by Lockyer and by Exner and Haschek, 63 lines in all, can be identified with the more intense of the lines now obtained. The absorption spectrum, comprising uniquely the principal series, was also photographed. Measurements of the doublets, from No. 2 to No. 26, agreed well with Bevan's results [Abs. 851 (1912)]. The paper concludes with a wave-length table of the new spectrum. **A. W.**

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HEAT.

1913. *Thermal Expansion of Certain Solids.* **I. K. Scheel.** (Zeits. f. Physik, 5. 2 and 3. pp. 167–172, 1921. From the Physikal.-Techn. Reichsanstalt.)—Measurements of the linear expansion of aluminium, magnesium, silver, Jena glass (4 varieties), quartz glass, porcelain, platinum-iridium, "Invar" (2 varieties), and speculum metal have been carried out by one or both of the following methods (*a*) and (*b*) :—

(*a*) *Tube Method.*—The rod A to be examined is placed vertically in a tube closed at the bottom, where it is supported on a flat point fused into the base of the tube. On the upper surface of the rod A is another rod, B, made of the same material as the tube (quartz or Jena glass), whose coefficient of expansion between the limits desired have been correctly determined by Fizeau's method [see (*b*)]. The rod B and the jacket tube are polished and graduated at their upper ends. The expansion of A is then measured relatively to that of the tube and the rod B. The whole is enclosed in a constant-temperature enclosure. Observations were carried out at − 78° in solid CO_2, at 100° C. in steam, at 200° in methyl benzoate vapour, and at higher temperatures in an electrically heated bath of saltpetre.

(*b*) *Fizeau's Method* [see Abs. 688 (1914)].—The linear expansions of rods about 9·5 mm. long were determined relatively to that of a quartz glass ring 10 mm. high at 0° C., whose expansion between − 252° and 500° had been carefully determined, and could be expressed between 0° and 500° by the relation $\Delta l = 0{\cdot}0395\tau + 0{\cdot}01282\tau^2 - 0{\cdot}001698\tau^2$. Here Δl is the linear expansion in mm. of a rod 1 metre long at 0° C., $\tau = t/100$ where t is degrees C., and α, β, and γ are constants. Observations up to 500° C. were carried out in an electrically heated air bath. The furnace consisted of an asbestos-covered porcelain tube 5 cm. wide and 14 cm. long, standing vertically on a stone slab. The tube was covered inside and out (beneath the asbestos) by a thin Pt sheet 0·1 mm. thick through which the electric current was led. The temperature was measured by a thermo-junction inside a small Fizeau dilatometer. Results are given in tables and also by means of equations of the form $\Delta l = \alpha\tau + \beta\tau^2$. [See next Abstract.] T. B.

1914. *Thermal Expansion of Certain Solids.* II. **J. Disch.** (Zeits. f. Physik, 5. 2 and 3. pp. 173–175, 1921. From the Physikal.-Techn. Reichsanstalt.)—Method (*b*) described in the preceding Abstract has been applied to the measurement of the linear expansion of chromium, manganese, molybdenum, nickel, tantalum, tungsten, and "elektron" (an alloy of Al and Mg). Observations were carried out at room temperature, at − 190° in liquid air, at − 78° in solid CO_2, and from 100° to 500° in an electrically heated air bath. In some cases (*e.g.*, Mo, Mn, Wo, Ta, and "elektron") measurements could not be made at higher temperatures than 300° or 400° because of indistinctness in the interference fringe system. Results are given in tables and in formulæ similar to those of the preceding Abstract. The formula given for Ni is applicable only up to 400° C., in the neighbourhood of which temperature there appears to be an anomaly in its behaviour as to expansion. T. B.

SOUND.

1915. *Frequency-Meter of Telephonic Range.* **A. E. Kennelly** and **C. Manneback.** (Frank. Inst., J. 192. pp. 349–359, Sept., 1921.)—Describes an arrangement of a vertical monochord with weighted wire and adjustable bridges, which can be set to respond to the frequency of a telephone whose poles are close to the centre of the wire. Thus the frequency of the vibrations in the telephone (and so of their source) is readily calculated. The paper gives good diagrams and photographs of the apparatus and discusses its calibration and accuracy. E. H. B.

1916. *Origin and Nature of Aeroplane Sounds.* **E. Waetzmann.** (Zeits. techn. Physik, 2. 6. pp. 166–172, 1921.)—Discusses the sounds heard from various aeroplanes when approaching, overhead, and receding. Records of the wave-forms are also given with analyses of the components. It is shown that the chief frequencies heard usually range from about 96 to 384 per sec., though fainter sounds of still lower and higher frequencies are often present also. E. H. B.

1917. *Audibility of Aeroplane Sounds.* **E. Waetzmann.** (Zeits. techn. Physik. 2. 7. pp. 191–194, 1921.)—Following up a previous paper, the author now passes to the problems of increasing the audibility and improving the directive perception of the naked ears for aeroplane sounds [see preceding Abstract]. Experiments are described with funnels of various forms and sizes, including a parabolic one of 3·2 m. diameter of opening and 0·8 m. in depth. Some observations showed that the use of funnels doubled the audible distance for noises and increased by 50 % that for the deep tones. E. H. B.

1918. *New Acoustical Phenomena.* **J. Erskine-Murray.** (Nature, 107. p. 490, June 16, 1921.)—In the early part of the war the author noticed that the higher pitched sounds apparently given out from an aeroplane flying nearly overhead varied with the height of his ear above the ground ; thus, by bending to half his normal height, the pitch of this higher note rose an octave. On many recent occasions this result has been confirmed. The phenomenon is most noticeable when standing on a smooth road or lawn, and is scarcely distinguishable on a rougher surface, such as a hayfield ; the logical conclusion is therefore that it is due in some manner to reflection from the ground. The pitch of the note varies also with the angle of elevation of the aeroplane, and is not generally audible unless this exceeds 45°. Since the pitch rises continuously as the head is lowered, the apparent explanation is that the note is due to the interval between the arrival of the direct and reflected waves from impulses radiated from the aeroplane. The phenomenon has been observed under an aspen tree also. The pitch corresponds to the calculation by the speed of sound in air. E. H. B.

1919. *Speeds of Sound in Gases at Various Temperatures.* **F. Himstedt** and **R. Widder.** (Zeits f. Physik, 4. 3. pp. 355–359, 1921.)—Describes an apparatus which is to be used at high and low temperatures for the determination of sound speeds in partially dissociated gases (*e.g.*, $N_2O_4 \rightleftharpoons 2NO_2$) and the dependence of such speeds on the frequency. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1920. *Determination of the Elementary Electrical Quantum from the "Schrot Effect."* **C. A. Hartmann.** (Ann. d. Physik, 65. 1. pp. 51–78, May 13, 1921.]—This paper is concerned with the application of the thermionic amplifier to the determination of small electrical variations such as occur in ionisation currents or disintegration currents of radioactive material. The object is the measurement of the spontaneous current variations in high-vacuum discharge tubes, a subject which has been previously dealt with theoretically by Schottky and called by him the "Schrot effect" (literally, the small shot effect).

Schottky has advanced a formula $C = \sqrt{(2\pi)}\sqrt{(\epsilon i_0/i)}$ for the effective mean value C of the current, where ϵ is the elementary quantum. In terms of voltage variation V and impedance Z of the compared circuit $C = V/Z_0$ and $\epsilon = V^2/i_0\omega_0 Z_0^2$, where $\omega_0 = 2\pi/\epsilon$.

The particular type of two-electrode valve used in the experiments is then illustrated and described in great detail, as also the bridge and telephone and the oscillatory circuits used to make the comparison by aural means. A further apparatus for directly determining the value of ϵ is also illustrated and described, together with the theory of the methods used.

The author summarises his results as follows:—(1) The quantum effect is greater than if due to purely thermal effects and diminishes with increase of frequency. (2) Investigations show the effect is not of external origin and (*a*) the internal resistance of the tube is independent of the frequency, but very dependent on the saturation current, and the tube has capacity which increases with the saturation current; (*b*) the damping resistance of the oscillatory circuit depends largely upon the frequency, the self-induction playing only a small part. (3) Correction is made of Schottky's view that a change from infinite to zero in the ratio of valve resistance and impedance is necessary. (4) Exact measurements show the function $\epsilon(\omega_0)$ to have limiting values which are not due to errors of measurement. (5) It is demonstrated that the apparent smallness of the quantum effect is a function of the saturation currents. (6) It is advanced as a qualitative explanation of the effect, that it is due to the thermal conductivity of the filament and the influence of the emitted electrons upon the surface temperature of the filament. The Schottky assumption of its being an independent effect does not hold for the particular saturation current used. The apparent valve capacity has, likewise, to be attributed to thermal conductivity. B. J. L.

1921. *Rotation of Dielectric Fluids in a Rotating Electrostatic Field.* **P. Lertes.** (Zeits. f. Physik, 4. 3. pp. 315–336, 1921.)—The couple experienced by a dielectric fluid when situated in a rotating electrostatic field was measured for methyl, ethyl and amyl alcohol, distilled and ordinary water, ethyl ether, acetone, toluol, and nitrobenzol. The results are exhibited in tabular and graphical form, and are compared with the theoretical values deduced from Lampa's formula [Abs. 1055 (1907)]. A full description is given of the method of obtaining the rotating field and carrying out the observations. For the frequency region $3\cdot76 \times 10^4$ to $1\cdot88 \times 10^7$ a good agreement between theory and experiment was obtained. The discrepancies, with the exception of toluol, lie within the errors of experiment. The poor agreement in the case of toluol is considered to be due to inaccurate determination of the conductivity of this very feebly conducting substance. The marked disagreement occurring at low frequencies was traced to a hysteresis effect in the glass sphere containing the fluid. The research affords a means of investigating Born's dipole effect [Abs. 1029 (1920)], and it is shown that it is necessary either to employ very high frequencies for the rotating fields, or to separate completely the conductivity effect from the dipole effect. A. W.

DISCHARGE AND OSCILLATIONS.

1922. *Emission of Electrons from Metals under the Action of Intence Fields.* **G. Hoffmann.** (Zeits. f. Physik, 4. 3. pp. 363–382, 1921.)—The problem of the transfer of electricity between two metallic surfaces separated by a very small gap, apart from conduction through ionisation of the intervening gas has been the subject of several investigations. The discordant results obtained by different observers are partly due to the inherent difficulties of the experiment. Positive results were obtained by the author in 1910 [Abs. 122 (1911)]. The apparatus employed in the present investigation is essentially similar to that used in the previous work. Small variations in the width of the gap are controlled magnetically and observed by an optical interference method. The whole apparatus is enclosed in a metal case, and the temperature regulated by a thermostat. The pressure inside the case was maintained at 1μ by means of a Gaede pump. Greater sensitiveness in the measurement of the current was possible, the author's vacuum electrometer [Abs. 1308 (1917)] being used. The first set of observations were carried out with surfaces of the same metal opposed to one another, either Pt-Ir, Cu, Al, Zn, or Pb. The distance apart being of the order $420\,\mu\mu$ the p.d. was varied until a deflection of the electrometer could be observed. The smallest observable deflection was 1 scale div. per min. corresponding to a current of $3\cdot2 \times 10^{-17}$ amp. The characteristic potential drop to produce this current was of the same order for all the metals tested, ranging from $2\cdot2$ to $4\cdot8 \times 10^6$ volts per cm. A small increase in this characteristic field produced in all cases a very large increase of current. When dissimilar metallic surfaces are opposed the quantitative results depend upon the direction of the field. The author concludes from his experiments that there is positive evidence for the expulsion of electrons for a certain characteristic field. If this field be further increased then free metallic atoms will be expelled. By working with field strengths that are too high ultramicroscopic metallic dust will influence decidedly the results observed. L. L.

1923. *Uncharged Nuclei Produced in Moist Air by Ultra-Violet Light and other Sources.* **J. A. McClelland** and **J. J. McHenry.** (Roy. Dublin Soc., Proc. 16. pp. 282–303, Aug., 1921.)—The paper is summarised as follows:—(1) The nuclei produced by ultra-violet light in moist air are detected by an electrical method and their size is indicated by their mobility, when charged, in an electric field. The number as well as the size of the nuclei depend on the time of exposure to the light, the intensity of the light, and the amount of moisture in the air. The nuclei are probably small water-drops which owe their formation to the production in the moist air by ultra-violet light of some hygroscopic substance, such as hydrogen peroxide or oxides of nitrogen. An account of work by the experimenters is given, and the evidence, though inconclusive, points to H_2O_2 as the parent substance of the nucleus.

Some experiments were performed in air containing (instead of water) the vapours of methyl alcohol, ethyl alcohol, and toluene respectively. No nuclei were found by the method employed, probably because the nuclei grow so big and decrease so much in number that they fail to affect the currents in the apparatus.

(2) The nuclei which are emitted by a glass tube when heated not too strongly can be detected and measured in a manner similar to that used in the case of ultra-violet light. The nuclei can be charged by ultra-violet light, probably by the photoelectric discharge of electrons from the rather large particles. The positive ions are found to be much more numerous and of much greater size than the negative ions. In all probability only particles greater than a certain critical size are acted on by the light. The electrons then become attached to the smaller particles or the air molecules. The negative ions thus formed are numerically more decreased by diffusion to the walls of the apparatus than the large positive ions.

Experiments have been made on the recovery of glass fatigued by heat. At "glowing" temperatures the glass does not become fatigued and the nuclei are probably produced by the decomposition of the glass itself.

(3) When platinum wires are heated electrically, nuclei are driven off before the wire begins to glow. This emission lasts only a short time, just as in the case of glass, and is probably due to occluded impurities. When these impurities are driven off by heat the wire emits no nuclei until it begins to glow. The emission at glowing temperatures is very constant and not subject to fatigue. The size, as also the number of the nuclei emitted, increases with the temperature.

Similar results were obtained with wires of nichrome. A. B. W.

1924. *Effect of an Electric Current on the Photoelectric Effect.* **F. Horton.** (Phil. Mag. 42. pp. 279–280, Aug., 1921.)—Shenstone has described experiments in which a current through a plate or film of bismuth appeared to produce a considerable increase in the photoelectric emission from that metal [see Abs. 1808 (1921)]. The author here criticises Shenstone's conclusions, and suggests that the results may be accounted for as being due to the evolution of gases from parts of the apparatus, which become warmed by the current passing through the bismuth. An effect resembling that described by Shenstone was obtained by Ladenburg in his experiments on the photoelectric emission from platinum and other metals [Abs. 1061 (1907)]. A. W.

1925. *Photoelectric Conductivity of Zinc-Sulphide Phosphors.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 4. 2. pp. 206–210, 1921.)—As the result of this experimental work three graphs are given showing as ordinates the outflow of electricity per unit energy of incident light, the abscissæ denoting wave-lengths, which range from 240 to 500 $\mu\mu$.

It is thus shown that the spectral distribution of the photoelectric conductivity (or emission) of the Zn-S phosphor exhibits a general correspondence with phosphorescence. [See Abs. 449 and 914 (1921).] E. H. B.

1926. *Generation of Heat at the Anode in Discharge Tubes.* **L. Peters.** (Zeits. f. Physik, 4. 3. pp. 432–436, 1921.)—The discharge tube used was cylindrical in form, with short side tubes, one near each end. One of the side tubes carried the aluminium kathode, and the other the anode, a massive copper sphere, at the centre of which was situated an iron-constantan thermo-couple. A 1200-volt battery was used to produce the discharge. The method of research was similar to that employed by Hodgson [Abs. 728 (1914)]. Four types of discharge were used:—(i) Positive column unstratified, without dark space; (ii) as in (i), but with dark space; (iii) stratified positive column; (iv) no positive column. The results showed that in air, as well as in iodine, the heat generated at the anode corresponds to the energy which the electrons acquire (*a*) in the case of an unstratified column without dark space, solely by their passage through the anode fall of potential; (*b*) in the case of an unstratified or stratified positive column with dark space, by their passage through the anode-fall and the dark layer close to the anode glow; (*c*) in the case of the discharge having no positive column, by their passage from the beginning of the Faraday dark space. A. W.

1927. *Dielectric Cohesion.* **E. Bouty.** (Ann. de Physique, 16. pp. 5–34, July–Aug., 1921.)—In this memoir the author resumes a long series of investigations which have been interrupted by the war [see Abs. 1150 (1921)]. J. J. Thomson's opinion that rarefied gases should possess an electrolytic conductivity is first discussed, and his experiment described of placing the tube containing the gas at the centre of a short spiral traversed by the oscillating discharge of a Leyden jar, when a homogeneous luminous ring is seen which becomes particularly brilliant when the gas pressure is in the neighbourhood of 1/200 mm. If the gas tube be formed of two concentric parts, the experiment may be regulated in such a way that only the external tube is illuminated; the induction in the interior tube is then too feeble to produce luminescence in the gas. In order to evaluate the conductivity of the gas, the author substitutes for the gas a solution of sulphuric acid, whose concentration is adjusted so as to produce an electric gradient equivalent to that of the gas. It is then found that, instead of being exceedingly bad conductors, rarefied gases (at not too low a pressure) are, on the contrary, surprisingly good ones, having molecular conductivities enormously greater than those of any electrolytes with which we are acquainted.

While the author admits Thomson's experiment to be highly ingenious, he opines the conclusion arrived at to be paradoxical. Accordingly he now describes an absolutely different method of control employing an e.m.f. of an electrostatic character. If a conductor, whether metallic or electrolytic, or even a hollow body, be introduced into the uniform electrostatic field between the plates of an air condenser, the capacity of the condenser will increase as if the plates had been moved nearer together. This should also occur if a tube of rarefied gas be inserted, should the conductivity opined by Thomson exist. The test was made with various Crookes tubes, glow-lamps, etc., and proved fruitless, even when the condenser plates were distant 3 cm. and had a p.d. of 2000 volts. It is therefore impossible to liken a rarefied gas to a true electrolyte, since the latter immediately produces a change such as is described above. Tubes were then used without electrodes, and connected to a mercury pump, whereby the pressures could be regulated; it was found that the gas became a conductor in a definite critical field which was a function of the pressure and temperature of the gas. Under normal conditions, gases, even when rarefied, are perfect insulators, and, when subjected to the action of the field, which tends to render them conductors, they oppose to this action a determined resistance which can only be overcome if the field be sufficiently intense. The author terms this opposition to breaking the dielectric equilibrium, the dielectric cohesion of the gas, and the object of this paper is to fix the laws governing this dielectric cohesion by determining the minimum value of the field for effecting the transformation of insulator into conductor under various conditions of temperature and pressure. Chapter I describes in detail the methods employed and the preliminary results. In Chapter II thick layers of gas are investigated, Paschen's law is discussed, an interpretation is given to J. J. Thomson's experiment, and the rare monatomic gases are considered. The various effects of the dielectric walls and other complications are finally discussed and a table of dielectric cohesions concludes the chapter.

It is opined that the dielectric cohesion resides in the atoms and molecules. For all gases and vapours examined, the chemical stability and the dielectric stability appear to vary inversely as each other; the heavier and the more complex the molecule, the greater its chemical reactivity, *i.e.*, the less its stability and the greater the dielectric cohesion. H. H. Ho.

1928. *Minimum Potential of Electric Discharge in Hydrogen at Low Pressures.* **E. Dubois.** (Comptes Rendus, 173. pp. 224–225, July 25, and pp. 293–294, Aug. 1, 1921.)—Experiments on the minimum potential of discharge at low pressures are of a very delicate nature. For the most part sufficient care is not taken to eliminate the effects due to impurities. In the present experiments in which the discharge passes between a wire and a coaxial cylinder, great care is taken to avoid the known sources of error. Even with this care it is found that experiments show peculiar variations in the minimum potential of discharge in hydrogen; the higher values for this potential are obtained by allowing a discharge to pass in the apparatus and the lower values by afterwards heating the wire to dull redness in a vacuum. This would seem to imply since the greater part of the gas occluded in the wire is removed by heating, that this gas is the cause of the elevation of the potential observed after a discharge. Experiments were then tried to see if by heating the wire to a still higher temperature more of the occluded gas was removed. The conclusion is arrived at that the wire always contains traces of hydrogen; this gas showing a different attitude with respect to the metal according as it has been heated to a high or a low temperature. The suggestion is made that at low temperatures a true combination takes place between the metal and the hydrogen; this combination is destroyed at a very high temperature, leaving only hydrogen dissolved in the metal: the combination re-forms slowly if the apparatus is left to itself. Campbell held the view that when cold the platinum in his experiments was covered with a layer of hydrogen, which disappeared when the wire had been heated to whiteness. In the present state of the experiments it is not possible to decide which explanation is the correct one. A. E. G.

1929. *On the Canal-Ray Discharge.* **A. Rüttenauer.** (Zeits. f. Physik, 4. 2. pp. 267–283, 1921.)—The author refers to the experiments of Wien, who found in the equilibrium condition of the canal-rays the ratio of positive rays p to the total rays (associated "a" + positive p) in hydrogen to be 0·18 at low pressures and 0·28 at high pressures. The ratio $p/a = \omega$ of the positive particles (p) to the neutral particles (a) lies therefore between 0·22 and 0·39.

The author now makes a detailed investigation of the factors influencing this ratio, and tables of results are given in the paper indicating the effects of voltage, gas pressure, nature of gas, etc., on the value of the ratio.

If detailed information is required the original paper should be consulted. A. B. W.

1930. *Radiation Qualities and Voltage with the Coolidge Tube.* **H. Behnken.** (Zeits. techn. Physik, 26. pp. 153–160, 1921. From the Physikal.-Techn. Reichsanstalt.)—In soft X-ray tubes the radiation properties depend on the quantity of gas, whereas in the hard Coolidge tube the radiation properties are only dependent upon the external properties of the high-voltage source actuating the tube. The effect of voltage has been investigated by many physicists, and Einstein has advanced the formula $V\lambda_0 = 12\cdot3$, which agrees with experimental facts, λ_0 being the wave-length, in angstroms, of the hardest rays. The wave-length is the exact physical measurement of the ray qualities, and is related to the absorption coefficient μ as follows: $\mu = A\lambda^{2\cdot8}$, where A is a constant for the absorbing material. If it is wished to introduce the "half-value thickness" H we can use the well-known formula $H = 2ln/A\lambda^{2\cdot8}$. The author then puts forward a more complicated formula to express in a more directly useful form the relation of voltage and wave-length, namely: $E_v v^2/c = Qv^{2\cdot8}[1 - e\exp\{-q/v^{2\cdot8}.(v_0 - v)\}]e^{\mu v d}$, where $v \times 10^{18}$ denotes the frequency of the radiation and is connected with the wave-length by $v \times 10^{18}\lambda = c =$ velocity of light in cm./sec. E_v is the intensity at which the radiation of frequency $v \times 10^{18}$ occurs, and the voltage V is connected as $v_0 \times 10^{18} = c/\lambda_0 = cV/12\cdot3$. Q and q are constants which depend essentially on the antikathode material, Q depends on the choice of units and can be put equal to unity when definite units are not used, and q for tungsten is approximately 3·6. The factor $e^{-\mu v d}$ gives the absorption effect of the glass wall of the tube, where μ is the coefficient for a frequency of $v \times 10^{18}$, and d is the thickness of the wall in cm. For practical purposes it is better to replace v and v_0 by the wave-lengths λ and λ_0, and E_v, the energy of the wave-length, by E, the relations being then $E_\lambda = E_v v^2/c$ and $v = c \times 10^{-18}/\lambda$. By means of this equation a series of curves are given, having E_λ as abscissæ and λ in Ångström units as ordinates to show the effect of voltage, at constant currents up to 70 kv. These curves are discussed; they all meet the x axis at the value 1·15 Å., since at this wave-length they are soft and are absorbed by the tube walls.

The author then proceeds to compare by this method the relative efficiencies of tubes excited by interrupted direct current, sine-form alternating current and rectified alternating current; these have intensity efficiencies in the order given. The relative intensities are to be sought in the current form. With sine-form current only that portion of the energy in the neighbourhood of the peaks is effective in exciting hard

V.2
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waves, and the rest of the cycle gives off soft waves which are absorbed by the walls, so that the efficiency as compared to d.c. excitation is as 1 : 0·7. He next deals with the use of a synchronous needle interrupter, which prevents excitation of the tubes, except by the peak regions; but as Voigt has shown, such an interrupter may act as a spark-gap and cause h.f. oscillations at the peak values which is not an advantage but, since the amplitude of the oscillations is not constant, may be a disadvantage, and the efficiency may decrease. Finally, a third interrupted current is discussed, in which the voltage rises and falls in a linear manner to give a number of impulses of inverted V shape. Such a method of excitation is, however, inferior to the sine form, as it gives an efficiency of only 1 : 0·58, whereas the desired ratio of peak voltage to effective voltage is 1 : 1. B. J. L.

1931. *The Electric Point Discharge as Purity Test of Nitrogen.* **M. Pirani** and **E. Lax.** (Wiss. Veröff. d. Siemens-Konzern, 1920. Elekt. Zeits. 42. p. 951, Aug. 25, 1921.)—According to Franck and Hertz collisions between gas molecules and electrons are elastic when there is no electronic affinity, but inelastic where there is affinity, and the electric conductivity of an inert gas is hence first increased, and then decreased by the addition of another gas. The authors study the discharge between a disc electrode of 30 mm. diam. and a point electrode, both of aluminium, through a gap of 50 mm. in an atmosphere of nitrogen at 700 mm. Hg. In pure nitrogen the current intensity rises to a maximum in a few minutes. On the addition of very small percentages of oxygen (10^{-5} to 10^{-3} per cent.) the current is decreased, and its rise to a maximum, which is higher than in pure nitrogen, takes 15 (instead of 3) minutes or more. By such observations impurities of 5×10^{-5} per cent. of oxygen can be estimated. On the addition of water-vapour the phenomena become more complicated. H. B.

1932. *Three Magnetically Coupled Circuits.* **L. C. Jackson.** (Phil. Mag. 42. pp. 35–46, July, 1921.)—The author investigates mathematically the problem of three resistant oscillating circuits, each of which is magnetically coupled to the other two. The method of calculation adopted is that of complex quantities; the damping factors are supposed small in order to be able to introduce necessary simplifications. The final equation arrived at is a cubic in ω^2, which means that in the three circuits there flow, in general, three currents of different frequencies. The solution of the general equation is not given. In the three examples developed in the article the resistances are supposed to be zero. In the first example two of the circuits are supposed to be identical and equally coupled to the third circuit: three frequencies exist in each circuit. In the second example the three circuits and the three couplings are supposed equal: in this case only two frequencies exist in the resultant system. In the third example, given as a check on the theory, the couplings are supposed zero, and, naturally, only a single frequency in the first circuit is obtained. E. B.

1933. *On the Form of Free Triode Vibrations.* **E. V. Appleton** and **B. van der Pol.** (Phil. Mag. 42. pp. 201–220, Aug., 1921.)—Describes experiments carried out by means of a Duddell oscillograph to determine the current variations in the circuits of a triode generator. The results are interpreted in terms of an oscillation characteristic obtained from the ordinary triode characteristics. The estimation of the amplitude of the anode current in terms of the oscillation characteristic and physical constants is described, and deviations from the method given are to be attributed to the large conductance between grid and filament during part of the grid voltage cycle.

When the anode circuit of a triode is closed the mean temperature is reduced by the heat lost in electronic evaporation not being equalised by the additional current *via* filament and anode. The emission therefore falls, and owing to finite thermal capacity of the filament an appreciable time is required to attain the final state. The effect of these temperature variations is considered in the case when the anode current varies as in a self-excited generator, and for an ordinary filament the effect is marked at frequencies as low as 16 cycles per sec., oscillograms showing filament cooling and reduced emission during the saturation phase of anode current. With a very thin filament this effect would be pronounced at telephonic frequencies, but at high frequencies the emission will be sensibly constant and dynamic and static characteristics will only differ slightly.

Variation of retroaction on the current form is studied, and the results are explained by the theory given, combined with cooling effect. Secondary emission is important at low anode potentials. The investigation of Joulean heat-effect of the filament by emission current is described, and it is found that reversal of the direction of flow of filament currents may cause an emission variation of 25 %.

A theory is put forward that the filament battery could be dispensed with, and the filament temperature maintained by the emission current itself after the discharge has once been started. B. J. L.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1934. *Thermoelectric Action and Thermal Conduction in Metals.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 7. pp. 98–107, March, 1921.)—The author gives a summary of the results obtained by working out his theory of thermoelectric action and thermal conduction. These have already been published in a series of papers. [See Abs. 1003 (1920), 926 (1921).] Starting with the hypothesis of dual electric conduction, that is, conduction maintained in part by the passage of electrons from atomic union to atomic union during the contacts of atoms with positive ions, and in part by " free " electrons in the comparatively weak fields of force called the interatomic spaces, the author derives an equation giving the conditions of steady state in a detached bar, hot at one end and cold at the other, and two equations for the conditions of equilibrium at a junction of two metals. For the detached bar the steady state is a current of associated electrons up the temperature gradient and an equal current of free electrons down the temperature gradient. This involves a freeing of electrons from atomic unions, ionisation, at the hot end of the bar, with absorption of heat, and re-association at the cold end, with evolution of heat. Evidently this is a process of conveying heat, and the question at once arises whether it is capable of accounting for the whole or any considerable part of thermal conduction in metals. At the junction of two metals, on the other hand, the conditions of equilibrium permit no cyclic or circulatory motion of the electrons.

The author obtains ten equations given by the properties of the metals, each metal being considered separately, and besides two Peltier-effect equations, and from these twelve equations he determines twelve characteristic constants for the metals. In a table is given for each of many metals, and for two alloys, the values of the six constants deduced to account for the observed or estimated values of the Thomson-effect, thermal conductivity, and Peltier-effect with respect to bismuth, in these substances. The values of the quantities obtained by experiment and by putting the given values of the constants into the author's formulæ are compared in the table. Another table gives the estimated ratio expressed in percentage of the number of free electrons to the number of atoms, including the positive ions, within the metal at 0° C.

While the mechanism described, convection of heat by means of a circulatory electric current, may be able to account for only a part, perhaps a small part, of the total heat conduction of metals, the author considers that enough has been done to show that the possibilities of this mechanism are worthy of serious consideration. J. J. S.

1935. *Thermopiles and the Law of Wiedemann-Franz; Copper-Phosphorus Alloys.* **G. Pfleiderer.** (Arbeiten d. Kaiser Wilhelm Inst. f. Kohlenforschung. 4. pp. 409–426, 1920. Zeits. f. Metallkunde, 13. p. 237, May, 1921.)—The efficiency of the transformation of thermal into electrical energy depends upon the thermoelectric force of the two metals used and upon the ratio of the thermal conductivity λ to the electric conductivity k of the metal, the efficiency being the higher, the smaller the ratio λ/k. According to Wiedemann-Franz this ratio has the same value for all metals, above 7×10^{-6}, when the thermal energy is measured in watt-seconds. There are numerous deviations from this law, especially among alloys, but all these deviations seemed unfavourable to the efficiency of thermopiles. Alloys of copper with little phosphorus or arsenic proved exceptional according to Rietzsch (1900). The author determines the λ and k values of alloys of Cu with 1·98 and 0·63 % of P at temperatures ranging from 20° up to 55°, and further of pure electrolytic copper. He finds for the ratio λ/k at 30° values 8·14 to 8·09, 7·8, and 7·06 for the two alloys and the copper in the order stated; for electrolytic copper Jaeger and Diesselhorst had found 6·94 and 7·01. The experiments were made with rods up to 40 mm. long and 4 mm. in diam. The results do not confirm Rietzsch, and so far no alloy seems to be known of less than normal ratio λ/k, which would promise to yield more efficient thermopiles. H. B.

1936. *Thermoelectric Force of Antimony-Cadmium* (50 %) *Alloys.* **F. Fischer** and **G. Pfleiderer.** (Arbeiten d. Kaiser Wilhelm Inst. f. Kohlenforschung, 4. pp. 440–447, 1920. Zeits. f. Metallkunde, 13. pp. 237–238, May, 1921.)—According to W. Haken (Dissertation, Berlin, 1910) and Eucken and Gehlhoff [Abs. 748 (1912)] alloys of Sb-Cd give the highest thermoelectric force known. The authors find these forces exceedingly variable in parts of the same material. By fusing the two metals together under different conditions (in crucibles, sometimes under a layer of LiCl + KCl, in sealed or open glass vessels, in air or hydrogen); they prepare 8 alloys, all approximately in equal proportions of Sb and Cd; the materials were the purest obtainable. The thermoelectric force has a steep maximum near 50 %, and this maximum is exceedingly sensitive, not owing to slight variations in the composition apparently, but rather to want of homogeneity caused by the cooling. The metallographic studies show that the solid stable compound SbCd (m.p. 456°) is very little dissociated in the solid solution. On cooling the fused alloy, however, crystals of an unstable alloy, probably Sb_2Cd_3, form near 410°, which subsequently pass into SbCd by interaction with the Sb in the solid alloy. This transformation is fairly complete as a rule; for the once solidified alloy may be heated to about 445° without melting again; yet there may be incomplete transformation or further complexity. When the alloy was inoculated with crystal germs of the solid in order to suppress any tendency to the formation of other crystals, the thermoelectric force remained unsteady; but the force measured in couples of the alloy with copper rose to a maximum of 543 microvolts (Haken's maximum was 308, average 305) per 1 deg. C. When the alloy was fused under a layer of KCl + LiCl, the force was always low, 150 to 175 microvolts; when the alloy was subsequently heated, the thermoelectric force would generally, but not always, increase. Amalgamation lowered the thermoelectric force.

H. B.

1937. *Determination of the Thermal and Electric Conductivity of Metals.* **G. Pfleiderer.** (Arbeiten d. Kaiser Wilhelm Inst. f. Kohlenforschung, 4. pp. 429–439, 1920.)—The method used in the experiments of the preceding Abs. is a modification of the method of Lees. The rod of the substance under test is placed vertically between two blocks of copper, the lower block cooled by water, the upper heated by nichrome wire. Good contact between the ends of the rod and the block is secured by amalgamation; the space between the parts and the casing is packed with compressed cotton wool. The electrical energy is measured which is required to keep the temperature constant, and the experiment is repeated after removal of the rod; thus the heat flow through the rod and λ are determined. To find k the intensity and p.d. of an electric current passing through the rod are measured. H. B.

1938. *New Property of Semi-Insulators.* **G. Reboul.** (Rev. Gén. d'Él. 10. p. 393, Sept. 24, 1921. Paper read before the Assoc. franç. pour l'Avancement des Sciences, Rouen.)—The author has shown recently [Rev. Gén. d'Él. 10. pp. 94–96, July 16, 1921] that heterogeneous semi-insulators, under the application of a p.d. under suitable conditions, affect a photographic plate in such manner as to lead to the conclusion that these substances emit, under such conditions, a remarkably absorbable invisible radiation. In the present communication he describes his determination of the absorption coefficients of air and thin collodion films, which are of the same order as recently obtained by Hollweck for rays intermediate between the ultra-violet and X-rays. Using a p.d. of 450 volts a radiation of wave-length 30 Å. was obtained, and found to be completely absorbed by between 3 and 4 mm. of air, or by a collodion film of thickness 10^{-4} cm. G. W. DE T.

1939. *A New Property of Slight Conductors of Electricity.* **L. Amaduzzi.** (Comptes Rendus, 173. pp. 222–224, July 25, 1921.)—Reboul has published some observations showing a new property of bodies which are only slight conductors of electricity [see Abs. 1149 (1921)]. The author has repeated Reboul's experiments, and has made use of an arrangement by which the discharge between the sheet of paper and the electrodes is eliminated, and he has also impregnated the paper used with solutions of different salts. By this means some new features have been noticed, and it has been established that the passage of the current in the paper sets up an opposing electromotive polarisation force which makes it appear that there is a preliminary electrolytic process in the manifestation of the phenomenon, a process which, however, may be accompanied by no action likely to make an impression on the plate, but only by an action preparatory to the last phase, constituting perhaps the particular discharges brought about by Reboul. The effect of a magnetic field upon the phenomenon was also tried. A. E. G.

1940. *Dielectric Constants of Electrolytic Solutions.* **R. T. Lattey.** (Phil. Mag. 41. pp. 829–848, June, 1921.)—Reference to previous work is made, and it is remarked that practically all methods of determining the capacity of a condenser whose plates are separated by a conducting medium involve the use of alternating currents, and that the results obtained are only trustworthy when proper corrections are made for the current passing through the condenser by conduction. The two possible means of absorption of electrical power by imperfect insulators in an alternating field—due to (*a*) their conductivity, (*b*) dielectric polarisation—are discussed, and the present work confirms previous investigations in that, except at very high frequencies, aqueous solutions show only the first type. The nature of the circuit employed in the present investigation is described, and its relationships are established. Possible methods of tuning are also discussed. In the present work, the electrolytic condenser is connected in parallel with a variable air condenser, and tuning obtained by varying the latter. The electrolytic condenser is then removed, and the air condenser readjusted. Tables of calculated values are given illustrating the fallacy of the general assumption that exceedingly high frequencies are necessary for all methods of determining the dielectric constant of an electrolyte. Experiments with an improved form of apparatus are described, and tables given of the dielectric constants of water and of glycerol for varying wave-lengths. The dielectric constants of four typical solutions, namely: sugar, potassium chloride, copper sulphate, tetraethylammonium naphthalene β-sulphonate, are determined, the special features in each case being noted. An experiment is described showing that the dielectric constant of water, after correction for conductivity, is independent of the frequency between wave-lengths of 17 and 32 m. A. B. C. L.

1941. *High-Frequency Losses in Glasses and other Dielectrics.* **E. Schott.** (Jahrb. d. drahtl. Tele. 18. pp. 82–122, Aug., 1921. Extract from Dissertation, Jena.)—For determining the "angles of loss" of dielectrics in high-frequency fields a method was employed in which a direct comparison was made of the condenser (made up with the dielectric to be investigated) with an air condenser free from losses, and a previously calibrated resistance. The sensitiveness of the method was increased considerably by an arrangement for compensating the thermal current, so that resistance variations of the order of 0·001 ohm in the measurement circuit could be readily detected. The best air condensers ordinarily employed in practice, after improvement of the insulation, still show angles of loss of about 20 seconds with respect to precision air condensers [see Giebe, Abs. 2113 (1909)]. Variable air condensers of the Wagner or Schering and Schmidt type were found to be practically free from losses, and these were used in the research. The losses found for the different substances dealt with are given below:—

		Angle of Loss.
Different specimens of glass		1·5′ to 25′
Highest value for glass		90′
Quartz		0·4′
Good mica		0·6′
Pressed amber		18′
Presspan	about	100′

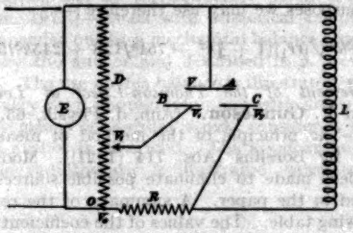
Dielectric Constant.—No dependence of the dielectric constant on the frequency was observed except in the case of dielectrics with considerable angles of loss, and even then a variation of less than 0·5 % was found, higher values being found as the wave-length was increased. The range of wave-lengths was from $\lambda = 300$ m. to $\lambda = 1600$ m. *Effect of Frequency.*—In the case of materials showing a large angle of loss, an increase or decrease with the frequency was observed, this signifying a predominance of some after-effect or conduction losses. With small angles of loss the variations were within the limits of error. *Temperature Effect.*—The increase of the angle of loss with temperature for glasses is very marked. At the highest temperature employed (about 400° C.) the loss can be assigned to pure conductivity. At ordinary room temperature the loss calculated from the d.c. resistance was generally much less than 1 % of the observed h.f. loss. *Mica.*—In the case of mica the angle of loss was shown to be independent of the plate thickness and capacity. A subsequent paper will deal with low-frequency and d.c. losses, and the combined results will be used to test the Schweidler-Wagner theory. A. W.

1942. *Electrification of Mercury by Friction; Relation between Triboelectric Effect and Volta-Effect.* **E. Perucca.** (N. Cimento, 22. pp. 56–67, July–Aug., 1921.)—In the experiments here described it is shown that the voltaic p.d. between mercury and a metal varies, and that this variation is ***pari passu*** with that previously pointed out in the case of the triboelectric effect. If the voltaic p.d. is plotted as abscissa and the triboelectric excitability as ordinate, the curve which expresses the relationship between the Volta-effect and the triboelectric effect is found to be almost a straight line. It is concluded that the cause of the two effects may be the same, but the processes which lead to the liberation of the electric charges in the two cases may be substantially different. A. E. G.

1943. *Measurement of Self-Inductance of Small Loops.* **F. B. Pidduck.** (Phil. Mag. 42. pp. 220–227, Aug., 1921.)—The method here described consists essentially in measuring the deflection of the small loop, which is suspended by a fine fibre, when subjected to an alternating magnetic field. The magnetic field is produced by two coils arranged in Helmholtz's fashion for a uniform field. In the zero position the small loop (a Cu or Al ring or small solenoid) was inclined at 45° to the common axis of the pair of coils. Formulæ are deduced for the self-inductance in terms of the deflection and the constants of the apparatus, and for the resistance in terms of the damping of small oscillations about the zero position and the constants of the apparatus, using a uniform constant field in the latter case. Experiments at low frequencies were made, and showed the method to give inaccurate results at low frequencies. At high frequencies, however, inductances from 20 cm. to 50,000 cm. were measured with an average error of about 1·5 %. A. W.

1944. *Alternating-Current Measurements with Amplifier Valves.* **F. F. Martens.** (Zeits. f. Physik, 4. 3. pp. 437–440, 1921.)—Describes a testing apparatus for carrying out d.c. measurements in valve tests, for making a.c. measurements to determine the ionic flow factor, and to measure the internal a.c. resistance of the valve. The necessary simple formulæ in terms of length of resistance wires, etc., are given, and also a diagram of a switchboard to facilitate rapid change in the connections for the various tests. B. J. L.

1945. *Balance Method of Using the Quadrant Electrometer for the Measurement of Power.* **H. Parry.** (Phys. Soc., Proc. 33. pp. 217–220; Disc., 220–221, June, 1921.)—The electrometer is used as a balance indicator, as shown in the Fig., where A represents the needle, B and C the quadrants, R a non-inductive resistance in series with the load L, D a calibrated potential divider, coupled between the potential point O on the supply side of R and the far side of the load, to which point the needle is coupled. E is a voltmeter.



The instrument must be free from electric control: that is the zero must not change when the voltage is applied to the needle with the quadrants short-circuited. The voltage on quadrant C is proportional to the current, and by means of the potential divider D a voltage can be applied to quadrant B, in phase with the needle voltage, such that the average torque on the needle is zero. If the power factor is unity the product of the voltages on the needle and quadrant B will be proportional to the watts expended in R and L. For other power factors $(VV_2/R)\cos\phi = VI\cos\phi = VV_1/R + (V_2^2 - V_1^2)/2R$ = the power expended in the resistance R and the load L. V is the voltage on the needle, V_1 that on quadrant B, V_2 that on quadrant C, the potential at O being zero. V_1 is calculated from the potential-divider data, and V_2 from the current and the resistance R, or measured with an a.c. potentiometer. The electrometer does not need to be so accurately made as for the deflectional method. In the *discussion*, **D. Owen** called attention to the advantages of using a null method, and said that he had tried the effect of connecting the needle to the mid-point of the non-inductive resistance across the mains. This had been previously suggested in the course of the discussion by **E. H. Rayner.** It not only eliminates the source of error occurring at low power factors, but simplifies the expression for the power. Denoting by V/n the voltage drawn from the potential divider (called by V_1 by the author) the expression for the power supplied to the load becomes $W = V^2/R \,.\, n - 1/n^2$. H. N. A.

1946. *Mutual Inductance of Two Coaxial Circular Currents.* **E. Mathy.** (J. de Physique et le Radium, 2. pp. 227–228, July, 1921.)—The author has previously given a formula for the mutual inductance of two coaxial circular currents in terms of Gauss's hypergeometric series [see Abs. 243 (1913)]. If r and r_1 be the radii of the circles, d the distance between their planes, and if we write $k^2 = 4rr_1/\{(r+r_1)^2+d^2\}$, his original formula becomes $M/2\pi^2 = k\sqrt{(rr_1)}[F(\frac{1}{2}, \frac{3}{2}, 2, k^2) - F(\frac{1}{2}, \frac{1}{2}, 1, k^2)]$, where the functions represent the hypergeometric series. Expanding and simplifying, he deduces that

$$M = \pi^2 k^3 \sqrt{(rr_1)}\left\{\frac{1}{4} + \left(\frac{3}{2}\right)^2 \frac{2}{6} k^2 + \ldots + \left(\frac{3\,.\,5\,.\,7\,\ldots}{2\,.\,4\,.\,6\,\ldots}\right)^2 \frac{n}{2(n+1)} k^{2(n-1)} + \ldots\right\}$$

For computing purposes we may use therefore :—

$$M = \frac{1}{4}\pi^{\text{[illegible]}}k^{\text{[illegible]}}\sqrt{(rr_1)}(1 + \tfrac{3}{4}k^2 + 75k^4/128 + 245k^6/512 \ldots)$$

A. R.

1947. *Measurement of the Thomson-Effect at Low Temperatures.* **G. Borelius** and **F. Gunneson.** (Ann. d. Physik, 65. 6. pp. 520–540, Aug. 30, 1921.)—The principle of the method of measurement is that previously given by Borelius [Abs. 714 (1921)]. Modifications of the apparatus have been made to eliminate possible sources of error; these are fully discussed in the paper. A summary of the results obtained is given in the following table. The values of the coefficient of the Thomson-effect are in microvolts per degree.

Absolute Temperature (Degrees) :—

	100	105	110	120	130	140	150	160	170	190	200	230	250	260	300	350	380	400
Cu ..	$\overline{0\cdot16}$	..	..	$\overline{0\cdot08}$	..	0·06	..	..	0·31	..	0·76	1·10	..	..	1·63	..	..	2·36
Ag ..	..	$\overline{0\cdot10}$	..	0·25	..	..	0·55	..	..	..	0·81	..	..	..	1·31	..	..	1·80
Au ..	0·29	..	..	..	0·71	..	..	0·96	..	..	1·18	..	..	..	1·61	..	..	2·05
Zn ..	0·8	..	..	..	..	..	1·1	..	..	..	1·25	..	1·55	..	2·6	..	5·9	..
Cd ..	..	..	$\overline{0\cdot65}$	..	..	..	0·0	..	..	0·55	..	2·7	..	..	7·1	9·3	9·8	..
Sn ..	0·86	..	..	..	0·85	..	..	..	..	..	0·42	..	..	..	$\overline{0\cdot07}$	..	..	$\overline{0\cdot45}$
Pb ..	..	..	..	$\overline{0\cdot19}$	..	..	$\overline{0\cdot30}$	..	..	..	$\overline{0\cdot45}$	..	..	..	$\overline{0\cdot68}$	..	..	$\overline{0\cdot85}$
Al ..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·11	$\overline{0\cdot08}$	..	..	$\overline{0\cdot56}$

L. L.

ALTERNATING CURRENTS AND MAGNETISM.

1948. *The Transformation of Iron at the Curie Point.* **P. Dejean.** (Comptes Rendus, 173. pp. 412–414, Aug. 22, 1921.)—The transformation of iron at the Curie point has been held by some to be an allotropic one, by others as purely magnetic in origin. The author describes experiments made to obtain evidence as to the nature of this change. A soft-steel rod 120 cm. long, 2 cm. in diam. was placed in a long solenoid and the flux through it measured for various magnetising currents in the solenoid. The solid rod was then replaced by one consisting of 120 short cylinders, 1 cm. long, 2 cm. in diam., cut from the same material. The air-gap between the individual cylinders was estimated at 0·065 mm. Further separation of the individual cylinders was secured by interposing discs of paper, cardboard, or wood, and magnetisation curves were obtained for different thicknesses of interspace. The curves coordinating interspace and magnetisation for different field strengths are similar to those obtained by Curie for intensity of magnetisation and absolute temperature. Elevation of temperature is analogous to magnetic separation. The separation might, however, be conceived as a progressive transformation from a magnetic α form, stable at low temperature, to a non-magnetic β form stable at high temperatures. L. L.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1949. *Problems of Radiography and Radiotherapy; Application of the Radiology Balance.* **M. de Laroquette.** (Arch. d'Él. Médicale, 29. pp. 161–191, June, 1921.)—Deals with numerical calculations of radiographic intensities carried out by a mechanical balance apparently designed for this purpose by the author and described in a previous paper [see Abs. 1478 (1921)]. The use of this balance is illustrated, with and without a screen, and for very deep photography, and with filters. The measurement of output by means of pastilles is next considered and a tintometer scale used by the author is described. The application to the measurements of doses in radiotherapy is illustrated, tabulated results being given. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1950. *Periodic Table. Modification more in Accord with Atomic Structure.* **I. D. Margary.** (Phil. Mag. **42**. pp. 287–288, Aug., 1921.)—In view of the recent advances in the elucidation of atomic structure which show that the inert gases of the helium group are the *final* members of each series of the periodic table, it seems desirable to have the usual simple form of the table arranged in a manner which shows this clearly.

It could be done quite easily by placing the group on the right of the table after Group VII, as shown in the original, instead of in its customary place on the left in front of Group I.

Such a plan would indicate that each member of Group 0 had the completed electronic arrangement for the series in accordance with the accepted theory, and would show clearly that a new series was commenced by each of the alkali metals of Group I. The present tables, on the other hand, would rather suggest that Group 0 formed the commencement of each series. The new arrangement, moreover, places helium in a separate series along with hydrogen, thus indicating the innermost electronic grouping of 2, which is ignored in the present tables, and also giving a relation for hydrogen, which has hitherto failed to find a rational place at all. A. B. W.

1951. *Rate of Diffusion of Carbon into Iron.* **I[ris[Runge.** (Zeits. Anorg. Chem. **115**. pp. 293–311, Feb. 21, 1921. Engineering, **112**. p. 279, Aug. 19, 1921.—Abstract.)—The author heats iron wire (mostly electrolytic), 0·5 mm. thick, 25 or 50 mm. long, wound to a spiral of 2·5 cm. length, in an electric furnace in an atmosphere of some carbonaceous gas, and joins the wire to a bridge measuring to 0·001 ohm. The observed increase in the resistance is assumed to be proportional to the absorption of carbon; up to 1·5 % of carbon was taken up at 1000° C. in the experiments. The wire was first heated in nitrogen or hydrogen until the resistance became constant; this took 2 hours, during which the resistance would rise to 10 times its original value. The gas is then turned on: coal gas, or vapours of hexane, benzene, toluene, petrol, ether, methylalcohol, as such or diluted with hydrogen or nitrogen. The resistance rose, though not in all the experiments, rapidly at first, and generally became fairly constant in 40 minutes. Soot might settle on the wire, and in such cases the change in resistance was marked. The presence of hydrogen seemed to facilitate the penetration of the carbon. The results were not very concordant. But the absorption of 1 % C increased the resistance by 5·7 % at 920°, by 7 % at 830° and by 40 % at 18°; the diffusion coefficient was about 2×10^{-7} sq. cm. per sec. at 930° C., and in an active gas 0·6 mgm. of carbon passed through 1 cm.^{2} of iron surface in the first 3 minutes. There was no appreciable cementation of the iron below 700°. The rate of cementation rose rapidly with higher temperature. The results of microscopic examination of the wires are also given. It is concluded that the carbon penetrates into the iron mainly in the gaseous condition, but solid penetration seems also possible. Reference is particularly made to the experiments of Giolitti, Astorri, and Carnevali [Abs. 1617 (1911) and 235 (1912)]. H. B.

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1952. *Spectroscopic Examination of Converter Flame.* **W. J. Campbell.** (Engineer, 132. pp. 137–138, Aug. 5, 1921.)—Points out that the spectroscope is more extensively used on the Continent than in this country for the examination of the Bessemer converter flame. In many Belgian and Swedish foundries the blow is ended before the flame has completely dropped, thus giving metal containing 0·4 to 0·6 % carbon to which suitable molten additions are made, the resultant metal running extremely hot and fluid. The spectroscope is useful for indicating the point at which to end the blow and enables more uniform results to be obtained. At the beginning of the blow the spectrum is continuous and indefinite. For a short period the sodium line is faint and appears in flashes; as the flame gradually increases and becomes steady, the sodium line becomes stationary and brighter. As the flame and temperature rise, the spectrum lines become more complex. The line spectrum of thallium and lithium and the banded spectrum of many other metals may be observed but are not of value for the control of the blow. The principal lines to be noted are the carbon lines, which appear bright green. They are faint at first, but gradually as the flame rises, they become brighter and more distinct until, with the falling of the carbon flame, they diminish in number and fade completely away with the final drop of the flame. An outline of an average blow and its spectroscopic examination is given; although the method of control is not infallibly accurate, a judgment of the carbon lines and the timing of their appearance is helpful in obtaining steel containing high carbon without recarburising. C. O. B.

1953. *Changes Produced during the Quenching of Steel.* **P. Dejean.** (Rev. de Mét. 18. pp. 419–427, July, 1921. [See Abs. 465 (1920).]—The Ar_3 point in steel represents the beginning of the change $\gamma \longrightarrow \alpha$ and separation of α from the γ solid solution, Ar_1 represents the eutectoid below which cementite is normally no longer soluble in iron (Ar_2 is explicitly ignored). These points may be lowered either by quenching or by the addition of certain elements such as Ni or Mn (passive resistances). Ar_3 is altered more than Ar_1 and may fall below it. Three cases are considered:—(1) If nothing hinders the separation of C the usual changes take place giving pearlitic or troostitic steel. (2) If passive resistances are present separation of carbon may not be complete at Ar_1. Patches of troostite or pearlite are then formed in a base of unaltered metal. The rest of the material is transformed at the lowered Ar_3 into martensite —a solution of cementite in α iron. (3) Ar_1 may be suppressed, the product being martensite alone. Martensite is said to be stable at low temperatures (up to 300° C. about), the limiting stability temperature falling with increasing carbon. J. L. H.

1954. *The Quenching of Steel.* **A. Portevin** and **P. Chevenard.** (Rev. de Mét. 18. pp. 428–444, July, 1921.)—The theory of the differential dilatometer is developed. Normally the standard material and the sample are at the same temperature, a straight-line curve resulting. A change of state in the sample changes its rate of heating or cooling and produces a difference of temperature between it and the standard. This difference increases with the rate of heating or cooling, which should be kept as low as possible. When the change of state is complete the sample heats or cools so as to catch up with the standard, and another break in the curve results, opposite in direction from that of the earlier one.

Honda's theory of quenching : Austenite $\leftrightarrows$ martensite $\leftrightarrows$ pearlite (or troostite), is criticised. It is stated that he ignored the theoretical limitations of the dilatometer.

Prolonged heating is needed to complete solution and diffusion of cementite in iron. Neglect of this produces local concentration of cementite, which is precipitated on cooling at too high a temperature. If the material may not be heated for long it should be taken 300–400 deg. C. above the transformation temperature, but cooled somewhat before quenching. Three states of the Fe–Fe_3C system exist: (1) solution of Fe_3C in γ-iron (austenite); (2) mixture of Fe_3C and α-iron (pearlite, troostite, or sorbite). Troostite is produced by falling, and sorbite by rising temperature; (3) solid solution of Fe_3C in α-iron (martensite).

The Fe-Ni system is discussed and illustrated, with some remarks on meteorites. J. L. H.

1955. *Allotropy of Zinc.* **K. E. Bingham.** (Inst. of Metals, J. 24. pp. 333–353; Disc. pp. 354–360, 1920.)—The previous work on the subject is reviewed, and experiments are described in which measurements were made on the electrical conductivity, thermal e.m.f., electrolytic potential, density, hardness, and mechanical properties of the metal, the measurements being carried out, whenever possible, at varying temperatures up to about 400° C., and otherwise on specimens quenched after annealing at these temperatures. The microstructure of the metal, and its changes as a result of heat treatment, is also fully dealt with. The results obtained by these methods are discussed, and it is claimed that they suggest very strongly that zinc has three allotropic modifications, the transformation temperatures being approximately 180° C. and 310° C.

In the *discussion*, **C. Benedicks** dealt with each of the methods employed by the author, and considered that the results left little doubt as to the existence of the three modifications; Miss **C. F. Elam** criticised the results obtained by means of the microscope, on the ground that similar effects might be obtained by the recrystallisation of slightly strained metal, and **W. Pierce** compared the results with those obtained at the research laboratory of the New Jersey Zinc Co. J. L. H.

1956. *Mechanical Properties of Steels at High Temperatures.* **E. Dupuy.** (Rev. de Mét. 18. pp. 331–365, June, 1921. Iron and Steel Inst., J. 104. pp. 1–22, 1921.)—Five samples of steel are used ranging from 0·15 to 1·23 % carbon and tested "as cast," "as cast normalised," "rolled," and "rolled normalised." A long test-piece is used projecting at each end from the furnace, which latter is composed of Pt wire for the lower temperatures and low-resistance carbon for the higher. Tensile strength and reduction of area are determined up to 1250° C. It is emphasised that the results obtained depend on the nature of the fractures, which are discussed in detail. The relation of the results with the equilibrium diagram is examined. J. L. H.